3. MATERIALS AND METHODS

3.1 Details of Trial Sites

3.1.1 Location

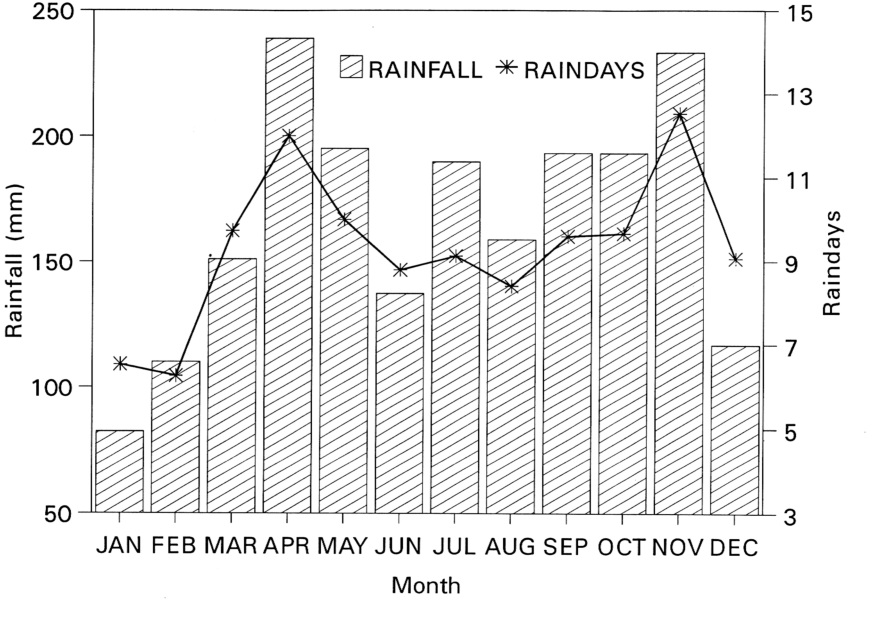
All four spacing trials concerned were established on SDP's Merlimau Estate, located 25 km south of Malacca City along the Merlimau-Jasin road. The predominant crops planted in Merlimau Estate were cocoa (68%) and rubber (30%) until 1994 when conversion to oil palm commenced, in line with SDP's shift in crop policy, in favour of oil palm.

3.1.2 Topography

Merlimau Estate is dominantly on very gently undulating low hills, slopes are mainly between 2 - 6° and seldom exceed 9°.

3.1.3 Rainfall

Rainfall data of Merlimau Estate for 1980 - 1994 period are presented in Fig. 3.01. The mean annual rainfall is 1998 mm with 113 raindays. Higher rainfall are received during April - May and July - November periods with monthly rainfall ranging between 160 - 240 mm with more than 9 raindays per month. Drier months are from December to March with monthly rainfall ranging between 80 - 115 mm. January is usually the driest month.


250
200
150
100
50
Rainfall (mm)
15
13
11
9
7
5
3
Raindays
RAINFALL
RAINDAYS
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Month

3.1.4 Soil

Rengam series (Typic Kandiudult) is the most dominant soil of the estate, occupying 92% of the area. The organic clay/sand and muck and local alluvium make up the remaining minor soils.

Rengam series soil in Merlimau Estate is derived from granitic/gneiss parent material. It occurs on very gently undulating terrain. The soil is deep, well-drained with coarse sandy clay sub-soil texture with fair moisture holding capacity. Majority of the soil are sandy (65% coarse sand) and have very low CEC ($\leqslant$ 4.0 cmo/kg^{-1}). They are easily depleted of soil nutrients. Summary of the various major soil nutrients status of the top soil and sub-soil of Rengam series sampled in 1992 at all trial sites is shown in Appendix 1. Rengam series is acidic with pH between 4.6 - 5.1. CEC is between 3 to 4 cmo/kg^{-1}. With appropriate soil/water management, soils of Rengam series are classified as suitable for oil palm, rubber and cocoa (Paramananthan, 1987).

3.2 Details of Experimentation

The four trials involved in the present study are outlined as follows:

3.2.1 Trial 1 - Double hedgerow high density planting of clonal cocoa

Established in late 1986, the first spacing trial on clonal cocoa evaluates the double hedgerow system of high density planting of selected budded clonal cocoa, with/without drip irrigation, on a typical Rengam series soil in Merlimau, Malacca.

Treatments and experimental design

The trial adopted the split-plot design with two replications, one of which is drip irrigated. The main plot and subplot treatments are detailed as follows:

Mainplot - Spacing/density

(A) Hedgerow System

Treatment	Wide interrow (m)	Close interrow (m)	Within row (m)	Density (trees/ha)
A	3	1	1	5,000
B	3	1	1.5	3,333
C	3	2	1.5	2,666
D	4	2	2	1,666
E	4	2	3	1,111
F	4	2	4	833

(B) Conventional System

Treatment	Between row (m)	Within row (m)	Density (trees/ha)
G	3	4	833
H	3	3	1,111
I	3	2	1,666
J	2.75	3	1,155

Sub-plot - Clone

Treatment	Clone	Plant Vigour	Canopy structure description
i)	PBC 112	Good	Dense
ii)	PBC 128	Moderate	Moderately dense
iii)	PBC 140	Very good	Dense
iv)	PBC 159	Moderate	Sparse

The clonal cocoa were planted out as 6 - 8 month old nursery-raised budgrafted seedlings.

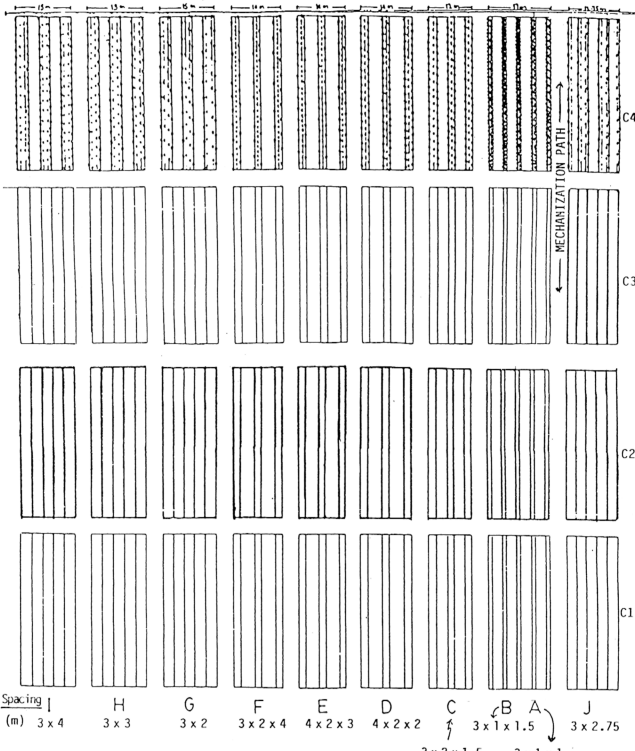
Each sub-plot consists of 6 rows per clone and measuring ca 14 x 43 m with the central 4 rows as recording core. Fig. 3.02 shows the trial layout with drip irrigation.

Fertiliser rate/Shade establishment

During immaturity (establishment phase), fertiliser application was on per bush basis and on maturity (productive phase), switched to per hectare on normal estate rates (120 kg N, 120 kg P205, 170 kg K20, 20 kg MgO plus 500 kg ground magnesium limestone per annum) which were subsequently increased by 50% at the 3rd year of yielding (1990/91). *Gliricidia* shade was initially established at ca 1,000 points/ha 12 months before cocoa planting and was thinned eventually to ca 136 points/ha by the 4th year.

Drip irrigation layout

The irrigation system which covered 50% (3.5 ha) of trial area (one replicate), used Rainbird EM10 pressure compensating emitters with a flow rate of 4 litres/hr which were placed at 1,155 emitter/ha. For hedgerow plantings, drip lateral lines are placed along the close interrows (Plate 1) while in the conventional planting, each planting row is served by a lateral line. The present drip irrigation system was set up at an



Note:

Lateral tubings are shared between 2 close rows

A-J = Spacing (Main plot)

C1-4 = Cocoa clone (Sub-plot)

Plate 1: Hedgerow planting of clonal cocoa with drip irrigation along the close interrow

installation cost of RM5,700/ha with annual operating cost of about RM700/ha. The criterion of irrigation was based on three consecutive days without rain and irrigation was for 6 hours per day in the morning.

Measurement/Recording

i) Growth measurements

Growth performance is gauged by measuring (a) stem diameter (main stem) at 10 cm from union and (b) plant height at periodic intervals during immaturity.

ii) Yield recording

Yield recording was by counting and marking mature pods at monthly intervals. Dry bean yields were derived by dividing total pods per hectare by pod value of individual clones which were determined periodically. Pod value index is the number of pods that produce one kilogram of dry beans.

Trial duration

Planting of clonal buddings was carried out in November/December 1986 and the trial was prematurely terminated in June 1994 when the cocoa were felled for conversion to oil palm following SDP's change in planting policy in favour of oil palm cultivation.

3.2.2 Trial 2 - Optimum conventional spacing of budded clonal cocoa

In the second trial, established in late 1987 on similar location, 7 conventional planting densities ranging from 672 to 3586 trees/ha with fixed interrow spacing of 2.75 m were evaluated on 7 clones and a F1 hybrid (as a check). The system of planting in this trial incorporated a 4.57 m wide interrow at every 6th interrow as mechanisation path.

Treatments and experimental design

The trial adopted the Split-plot layout with spacings as main-plots and clones as sub-plots with 5 replications, as follows:

Main plot (spacing/density)

Spacing	Interrow (m)	Within row (m)	Density (trees/ha)
i	2.75	0.91	3,586
ii	2.75	1.52	2,157
iii	2.75	2.29	1,432
iv	2.75	3.05	1,075
v	2.75	3.66	896
vi	2.75	4.27	768
vii	2.75	4.88	672

Sub-plot (Clones)

Cultivar		Plant vigour	Canopy description
F1 (commercial) clones	PBC 112	Very good	Very dense
	PBC 128	Moderate	Moderately dense
	PBC 130	Very good	Dense
	PBC 137	Good	Dense
	PBC 140	Very good	Very dense
	PBC 154	Very good	Very dense
F0 (Primary) clone	UIT 2	Good	Dense
F1 hybrid	UIT 1 x Na 32	Very good	Very dense

Each Sub-plot comprises 3 rows per clone and measures 8.25 m x 50 m with recording core of 3 x 8 trees (Fig. 3.03).

Fertiliser application rate

During establishment period, trees were fertilised on per bush basis and switched to per hectare basis on maturity at 120 kg N, 120 kg P205, 170 kg K20, 20 kg MgO plus 500 kg ground magnesium limestone per annum and fertiliser application rate was increased subsequently by 50% from 1990/91 period.

Shade

Gliricidia established initially at 2.75 x 3.05 m x (1,075 trees/ha) and progressively thinned to a final spacing of 8.23 m x 6.1 m (179 trees/ha) by the 4th year of cocoa planting.

Measurement/Recording

Growth measurements and yield recording were carried out as described in Trial 1.

Recording core (3x8 = 24 trees)
Clone 6
Clone 5
Clone 4
Clone 3
Clone 2
Clone 1
2.75 m
4.57 m
2.75 m
4.57 m
2.75 m
2.75 m
3.65 m
3.65 m
3.65 m
Mechanization Path
Mechanization Path
50 m
Cocoa
X Permanent gliricidle point

3.2.3 Trial 3 - Evaluation of high density planting of clonal cocoa using Systematic Fan Design

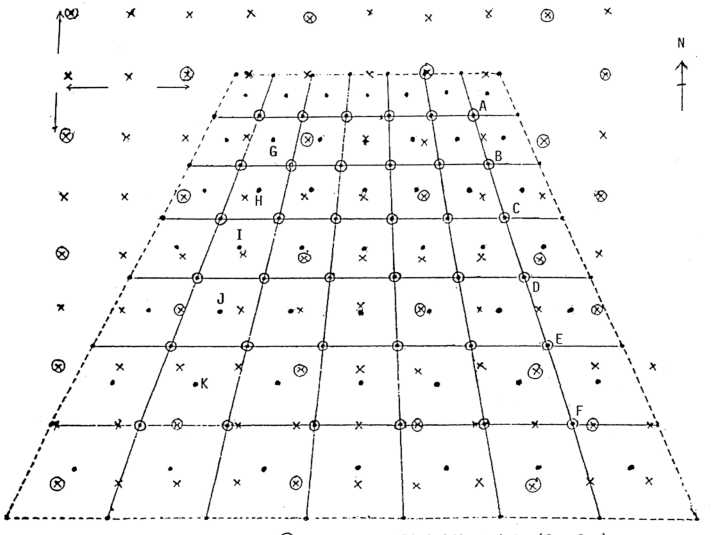
This trial was initiated in October 1988 to test a wide range of densities over selected PBC clones and hybrid seedling materials using the Systematic Fan Design layout which enables testing of wider density range over relatively small land area. In the present study, the original full circle layout had been segmented with each segment testing a clone at 6 final spacings, replicated six times.

Treatments

a) Spacing/Density

The trial was originally designed to test six permanent densisties viz 500, 800, 1100, 1400, 1700 and 2000 trees per hectare. Subsequently, it was modified to evaluate eleven "double" densities in the initial stage by inserting additional cocoa point in the centre between four permanent cocoa points (Fig. 3.04) with intention to eventually thin down to the six permanent densities by phasing out the inserted "temporary" cocoa points when yields decline set in. The eleven initial densities (trees/ha) evaluated were as follows:

1) 4,521	2) 4,202	3) 3,644	4) 3,189	5) 2,589
6) 3,427	7) 1,976	8) 1,842	9) 1,439	10) 1,297
11) 1,057				



Cocoa point	Density (stand/ha)
A *	4521
G	4202
B *	3644
H	3189
C *	2589
I	2427
D *	1976
J	1942
E *	1439
K	1297
F *	1057

* Permanent cocoa

⊗ Permanent Gliricidia points (6 x 6 m)

◉ Cocoa points (permanent spacings)

• Cocoa points (temporary spacings)

x Temporary Gliricidia points (3 x 3 m)

b) Planting material

6 PBC clones - PBC 123, 130, 131, 137, 140 and 154

2 Hybrids - UIT 1 x NA 32 and F1 mixed.

Due to insufficient clonal buddings at trial commencement, the temporary cocoa points were planted six months later than the permanent points.

Plot size

Each segment (clone) of 11 densities (5 temporary and 6 final) at 6 trees per spacing inclusive of single guard row all round occupies an area approximately 400 m^2.

Shade

Gliricidia maculata shade trees were established initially at 3 x 3 m and thinned eventually to 12 x 12 m final spacing irrespective of cocoa spacings.

Fertiliser rate

Immaturity - per tree) Based on normal estate rate as for TRIAL 2

Maturity - per hectare)

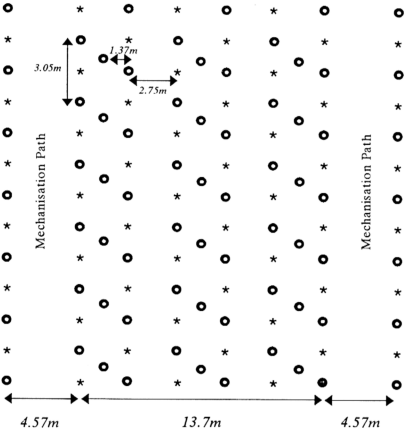
Thinning treatment

The intended treatment to phase out the temporary cocoa points when yield decline set in was not yet implemented when the trial was prematurely terminated in January 1994.

3.2.4 Trial 4 - High density planting of clonal cocoa on pilot commercial scale

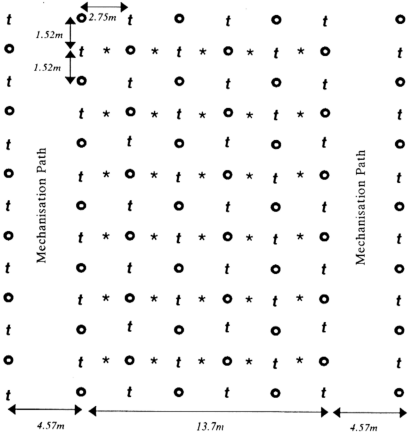
Encouraged by the favourable early indication of high density treatments in the earlier spacing trials, Merlimau Estate embarked on pilot commercial scale high density planting of clonal cocoa with variable configuration and densities up to ca 2,200 trees/ha. The incorporation of a 4.57 m mechanisation path at fixed intervals (13.7 m) was a standard feature of the planting. Details of five planting patterns/densities evaluated with the objective to test dynamic planting densities, ie. plant at "double" density initially and thin subsequently when yield per hectare declines are as follows:

1. Plant alternately at 1.37 x 3.05 m and 2.75 m x 3.05 m to achieve permanent stand of 1,620 trees/ha (Fig. 3.05a).
2. Plant initially at 2.75 m x 1.52 m (2,150 trees/ha).
   Subsequent thinning to 2.75 m x 3.05 m (1,075 trees/ha)(Fig. 3.05b).
3. Plant initially at 1.37 m x 3.05 m (1,970 trees/ha).
   Subsequent thinning to 2.75 m x 3.05 m (1,075 trees/ha)(Fig. 3.05c).

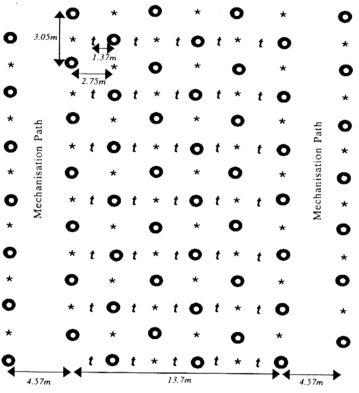


o *Permanent cocoa point*

* *Gliricidia shade*
(2.75 x 3.05m offset)



- *Permanent cocoa point*
- *Temporary cocoa point*
- *Gliricidia shade*



- o *Permanent cocoa point*
- t *Temporary cocoa point*
- ★ *Gliricidia shade*

4. Plant initially at 1.95 m x 1.95 m (2,195 trees/ha).

   Subsequent thinning to 2.75 m x 2.75 m (1,197 trees/ha) (Fig. 3.05d).

5. Plant at 2.75 m x 2.75 m to achieve permanent density of 1,197 trees/ha (Fig. 3.05e).

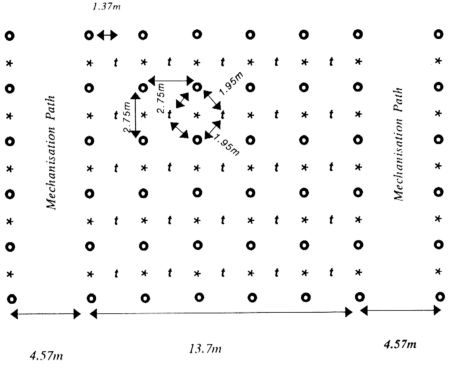
For shade establishment, except for planting (2), *Gliricidia* shade were planted along the cocoa rows in NS direction.

Fertiliser application regime were as preceding trials ie. on per tree basis during immaturity and on maturity, switched to per unit area on normal estate application rates.

Each spacing covered approximately 10 ha area with 8.5 m x 27 m recording core per clone.

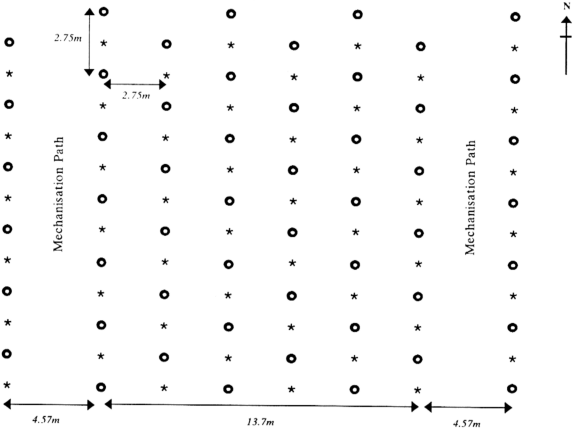
As with the preceding trials, growth measurements were taken annually for the first 3 years. Yield recording during maturity followed the standard procedure of mark and count mature pods at monthly intervals with periodic pod value determinations, for extrapolation of dry bean yields.

As a result of the change in planting policy of SDP in 1994, the pilot commercial scale high density plantings were prematurely terminated in June 1994 before the intended stand thinning treatments could be instituted.



N

- *Permanent cocoa point*
- *Temporary cocoa point*
- *Gliricidia shade*



Permanent cocoa point

Gliricidia shade

3.3 Canopy Light Distribution Measurements

The intended study on canopy light interception and distribution of the test clones at different hedgerow/conventional planting densities could not materialise due to decision by Sime Darby to convert all cocoa to oil palm plantings in Merlimau Estate. The decision compelled the premature termination of the foregoing spacing trials in second half of 1994 as complete removal of *Gliricidia* shade trees as well as the withdrawal of all normal agronomic and management inputs such as manuring, pest and disease control, weeding and pruning practices were enforced one year before the actual felling of cocoa trees took place in late 1994.